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13. ABSTRACT *(Maximum 200 words)*

Over the past funded year of the grant, significant progress has been made in a number of fields. These include regression sampling (forestry applications), factorial experiment, search design with quality control applications. Particular attention should be given breakthrough results on the Srivastiva sampling estimator in a joint paper with Z. Ouyang.

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Final
~~Annual~~ Report on the Air Force Grant ~~#~~[redacted],

For the One Year Period: April 15, 1989 to April 14, 1990

Principal Investigator: Jagdish Srivastava

Colorado State University

As in the previous years, high quality work continued to be done during the past year. Also, the volume of the work continued to be very large, as will be seen from the presentation below. We are very thankful to the technical monitors for their kind encouragement and support.

First, we would like to comment on the following papers:

a1) (with S. Arora) An infinite class of resolution 3.2 designs for the 2^m factorial experiment.

a2) (with S. Arora) On the minimal resolution 3.1 designs for the 2^4 factorial experiment.

a3) (with R. Hveberg) Sequential probing designs for identifying nonnegligible effects in 2^m factorial experiments, for $m \leq 3$.

a4) Some basic issues in design theory with special reference to response surfaces.

a5) (with Z. Ouyang) Sampling theory using experimental design concepts.

a6) (with Z. Ouyang) Study of the general estimator in sampling based on sample weight functions.

a7) (with Z. Ouyang) Minimax and admissibility properties of balanced proportional array strategy and strongly weight balanced strategy.

a8) Factorial design theory for experimenters.

The above papers were mentioned in the annual report of the last year. We would first like to discuss the status of these papers.

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Paper #a1 has been accepted for publication in the Annals of Discrete Mathematics. Paper #a2 has just appeared in "Coding and design theory, Vol. II", edited by D. Ray–Chaudhuri, Springer Verlag, 1990. Paper #a3 has just been revised according to the referees report. Paper #a4 is under print, and should appear shortly in JSPI. Papers #a5 and #a7 have been submitted to top statistical journals. A version of paper #a6 was completed last March, but later we decided to include a numerical example in it. We expect to complete this example shortly, after which the paper will be submitted to a top statistical journal.

Paper #a8 is a 98 page paper discussing the elements of the theory of factorial experiments in a way that it can be used by experimenters. It also contains some new ideas. This paper is under print in a volume on Experimental Design, being published by Marcel Dekker.

Paper #a1 is a long piece of high quality research in the theory of search designs which develops elegant discrete mathematics associated with these problems. Paper #a2 is a long paper containing tedious mathematical discussions, interlaced with computation work. Paper #a3 is a breakthrough paper which should start a new field in the subject. This new field will relax the assumptions being made thus far in the subject. These assumptions are sometimes very misleading, and as is now realized, they lead to production of bad quality products, among other things. Paper #a4 discusses the philosophy of design theory with a special reference to response surface technology. It shows how we can drastically improve on the response surface technology relative to what is being taught by certain groups in short lecture sessions.

Paper #a5 considers experimental design concepts and shows their inter–relationship with sampling theory. It lays the foundations of a group of ideas which should prove very beneficial in the future. Paper #a6 contains basic break–through type results on the estimator proposed by Srivastava several years ago, which has been highly acclaimed. Paper #a7 is high quality work on admissibility and minimax properties of certain sampling strategies. (It is well known that the study of such properties is an intrinsically difficult

problem.) Paper #a8 should be found very useful by all people who want to use the factorial design methods to design and analyze their experiments.

Besides the above papers, work for several new papers has also progressed. Many of these papers have already been written. We now describe these.

#b1 A 2^8 factorial design with good revealing power

#b2 (with Z. Ouyang and H. Schreuder) A general ratio estimator and its applications to regression sampling in forestry

#b3 A new estimator for the variance matrix under the hierarchical multivariate model and its applications to signal processing.

#b4 (with A. Khodadadi) Comparison of the new and the classical sensoring schemes under type I sensoring.

#b5 (with Z. Ouyang) Some properties of a new estimator in finite population sampling.

Paper #b1 has been submitted for publication. A positive referee's report has been obtained, and the paper has been revised in accordance with that report and re–submitted. Paper #b2 contains some very intricate developments using the Srivastava estimator in sampling theory, and applies this in the field of forestry. It is found that the new estimators beat most of the old estimators in most cases in actual populations arising in forestry.

Papers #b3 and #b4 have not been written yet. Paper #b3 contains a new estimate of the dispersion matrix under the hierarchical multivariate model. We also give the distribution of this estimator, which would be a generalization of the well known WISHART distribution, and the Mahalanobis–Bose–Roy distribution of rectangular coordinates. We are still working on many aspects of this. When written, the paper will show the importance of these results and their application to signal processing.

Work on paper #b4 is almost complete. As was explained in the reports in previous years, Srivastava had made a very major break through in the field of reliability. This consisted in developing censoring schemes for comparison of different brands of machines. It

was shown that the new censoring schemes were far superior to the classical schemes. However, in this study, censoring of type II was considered. (Under this procedure, experiments are conducted until a particular number of failures are observed.) However, we are now making the same types of studies under censoring of type I (wherein, experiment is continued for a predetermined time period, and then stopped). All concerned should be very happy to know that in censoring of type I as well, the earlier results hold true. Thus, if we want to continue the experiment until a fixed numbers of failures occur, or else if we wish to continue the experiment for a fixed time period, we have some very substantial improvements available.

Paper #b5 shows that some famous estimators in finite population sampling (such as Hartley–Ross, Mickey, and Midzano–Lahiri estimators) are special cases of the Srivastava estimator. A referee's report has been obtained on this paper, and the paper is being revised.

Besides the above, Srivastava has also connected the field of design theory with signal processing. For example, it has been observed that what has been called the Fast–Walsh–Hadamard–Transform (FWHT) in signal processing, is a re–discovery of the Yates algorithm, which has been well known in the design field since 1937. Other connections are being established. Indeed, under this series of grants, and in future years, it is hoped that the intimate connections that seem to exist between the design field and the field of signal processing will be well–established. Many papers should be expected in this field.

We would also like to report that work has been going on at a great speed in the field of optimal design theory and in design theory in general. One student is working for her Ph.D. dissertation in this field. Several papers are expected to be written in the coming year.

During the last one year period, Srivastava was, as usual, invited to a large number of places. However, because of health problems and other pressures, he could not go to all of them. However, he did go to several.

In particular, he gave invited talks at the University of Alabama (April 1989), at the meeting of the American Statistical Association, Washington, D.C. (August 1989),

International Conference on Data Analysis and Statistical Inference in Neuchatel, Switzerland (August 1989), and the University of North Dakota (February 1990). Srivastava was also invited to the International Conference in Mathematical Statistics in Lithuania (June 1989), Gauss Symposium (Rio De Janeiro, Brazil, July 1989), meeting of the American Mathematical Society (Muncie, Indiana October 1989). However, he could not go to these because of health problems and other pressures.